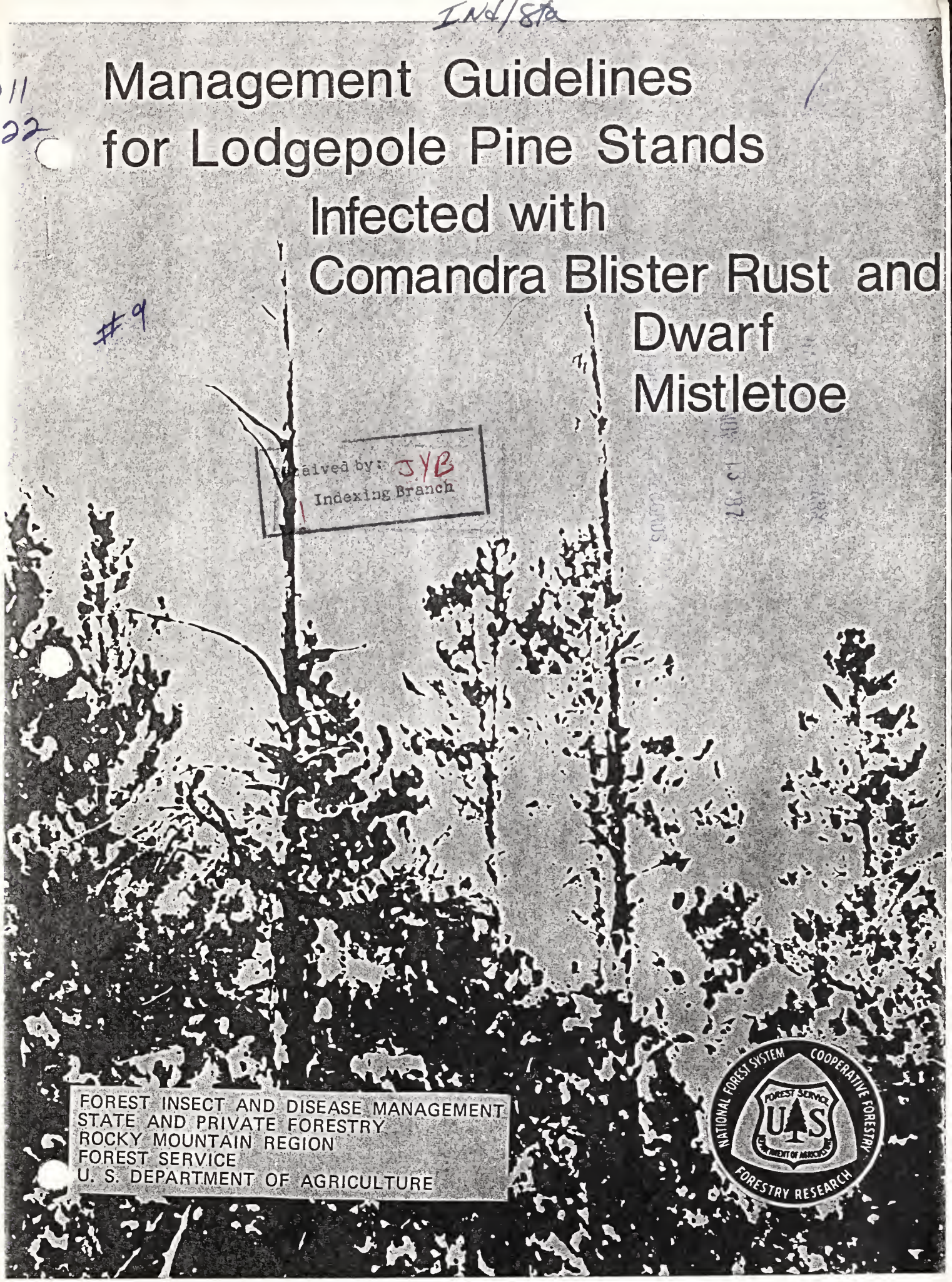
Management Guidelines for Lodgepole Pine Stands Infected with Comandra Blister Rust and Dwarf Mistletoe



FOREST INSECT AND DISEASE MANAGEMENT
STATE AND PRIVATE FORESTRY
ROCKY MOUNTAIN REGION
FOREST SERVICE
U. S. DEPARTMENT OF AGRICULTURE

MANAGEMENT GUIDELINES FOR LODGEPOLE PINE STANDS INFECTED WITH COMANDRA BLISTER RUST AND DWARF MISTLETOE

by

Donald H. Brown

Plant Pathologist

Technical Report R2-9

June 1977

Forest Insect and Disease Management
State and Private Forestry
Rocky Mountain Region
USDA, Forest Service
11177 W. 8th Avenue
Lakewood, Colorado 80225

TABLE OF CONTENTS

ACKNOWLEDGMENT

Grateful acknowledgment is expressed to Dr. Frank G. Hawksworth, Project Leader, RMFRES and Carleton B. Edminster, Research Forester, RMFRES, for guidance in the planning and conduct of this study.

The author also wishes to thank George L. Downing, Director, Forest Insect and Disease Management, R-2, for the opportunity to conduct this study on a part-time basis while studying for the ministry.

MANAGEMENT GUIDELINES FOR LODGEPOLE PINE STANDS INFECTED WITH COMANDRA BLISTER RUST AND DWARF MISTLETOE

PURPOSE

The purpose of this report is first, to review the occurrence, development, and management implications of the two most destructive diseases of lodgepole pine: comandra blister rust and lodgepole pine dwarf mistletoe; and secondly, to discuss silvicultural guidelines or recommendations for managing infected stands, based in part on two summers work of detailed stand examinations or surveys.

INTRODUCTION

Comandra blister rust, a disease native to North America caused by the fungus *Cronartium comandrae* Pk., is a damaging canker disease of hard pines. Host trees susceptible to the rust are: lodgepole, loblolly, ponderosa, jack, Scots, pitch, shortleaf, Mugo, Jeffrey, knobcone and Virginia pines. The disease alternates between pine hosts and herbaceous comandras. The comandra hosts are *Comandra umbellata* (L.) Nutt. var. *pallida* (DC.) M. E. Jones and *C. livida* Richards. The life cycle of the disease is completed only when the fungus successfully completes all growth stages on each host.

Comandra blister rust occurs from New Brunswick to the Yukon and British Columbia in Canada, southward to California, New Mexico and Alabama (13). It is most prevalent in the western United States, particularly in Idaho, Montana, Utah, and Wyoming. An early collection of the disease was made in 1906 on lodgepole pine in Colorado (9). By the early 1930's it had been collected in Montana, Idaho, Wyoming, Washington, Oregon and California. Wide-spread damage in lodgepole pine was not known until the mid-1950's when discovered by Dr. J. L. Mielke in Idaho, Utah and western Wyoming (12). In the 1960's increased occurrence and damage

was detected in Montana, parts of Colorado and the western provinces of Canada. However, later studies indicate that much of the current damage is from an epidemic that occurred between 1910 and 1945 (9, 14). More recent infections have occurred at an endemic level primarily on a very localized basis. The disease does not appear to be on the increase now nor is there any evidence that it will become catastrophic to lodgepole pine in the Rocky Mountain States (11). The disease also occurs on ponderosa pine in Colorado and the Black Hills of South Dakota.

Comandra rust on the pine hosts is perennial originating from spores produced on comandra plants that infect needle bearing shoots or stems in late summer or fall (Figure 1). These spores, which are thin-walled and easily dessicated, are probably limited in dispersion to only a few miles (10). The infections on pine develop in 2 to 4 years into spindle-shaped swellings or cankers. Two spore stages, pycnial and aecial, are produced annually beginning on 3- or 4-year old cankers. The pycnial spore stage is produced one year in advance of the aecial spore stage. In subsequent years both spore stages are produced on each canker. Aeciospores spread the disease to the alternate hosts by infecting the leaves of comandra plants. The aecial spore stage causes serious disruption and death of the phloem or bark tissue of the pine host by producing cracks that extend to the cambium (Figure 2). The cankers continue to enlarge eventually girdling the branch or stem causing those parts distal to, or beyond, the infection to die (Figure 3). The foliage of the affected parts turns yellowish- to reddish-brown. Stem cankers cause spike tops and eventually tree death (Figure 4). These characteristics plus heavy resin flow on older cankers are very typical of the disease. The principal types of tree damage include mortality, growth reduction, deformity and cull. Although height growth is generally terminated when top kill occurs, radial growth is not sharply decreased until two or three years before death of the tree (15).

The rust attacks host trees of all sizes and ages. Mortality of seedlings and saplings occurs more rapidly than for older trees which can take 50 or more years to die. The most extensive damage in the Rocky Mountain States has been observed in pole- and mature-size stands (9). The larger trees, usually those in the upper most crown classes, are more frequently damaged which results in losses that can postpone the economic maturity of infected stands (11). The proximity of comandra plants to lodgepole pine stands may directly influence the severity of infection (9). In many stands the heaviest amounts of infection tend to occur near the edge of stands. Comandra plants are usually not

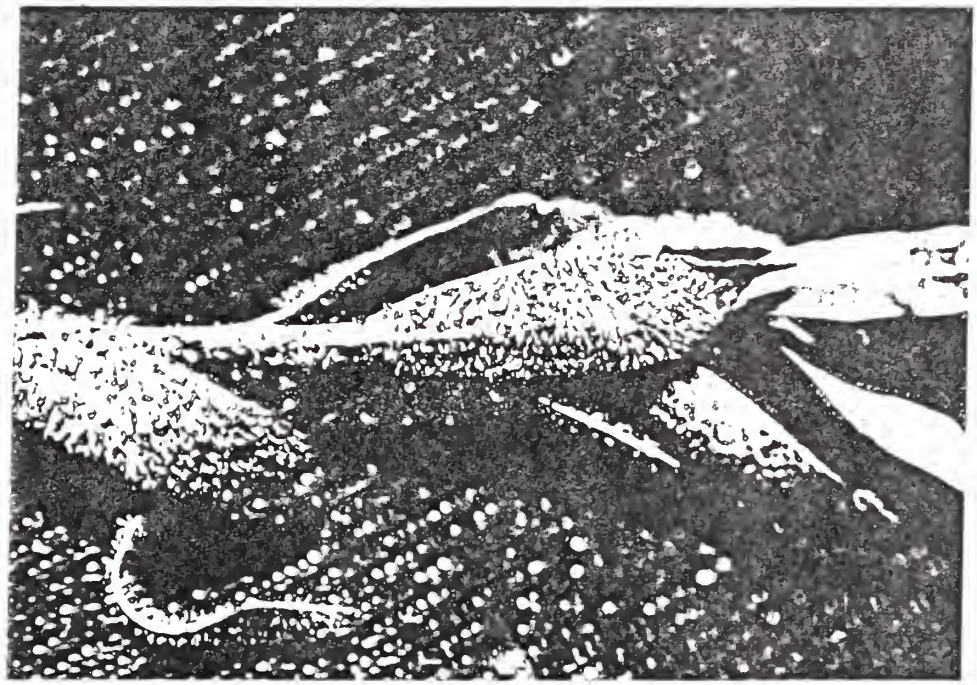


FIGURE 1 Infected comandra leaves producing pine infecting spores

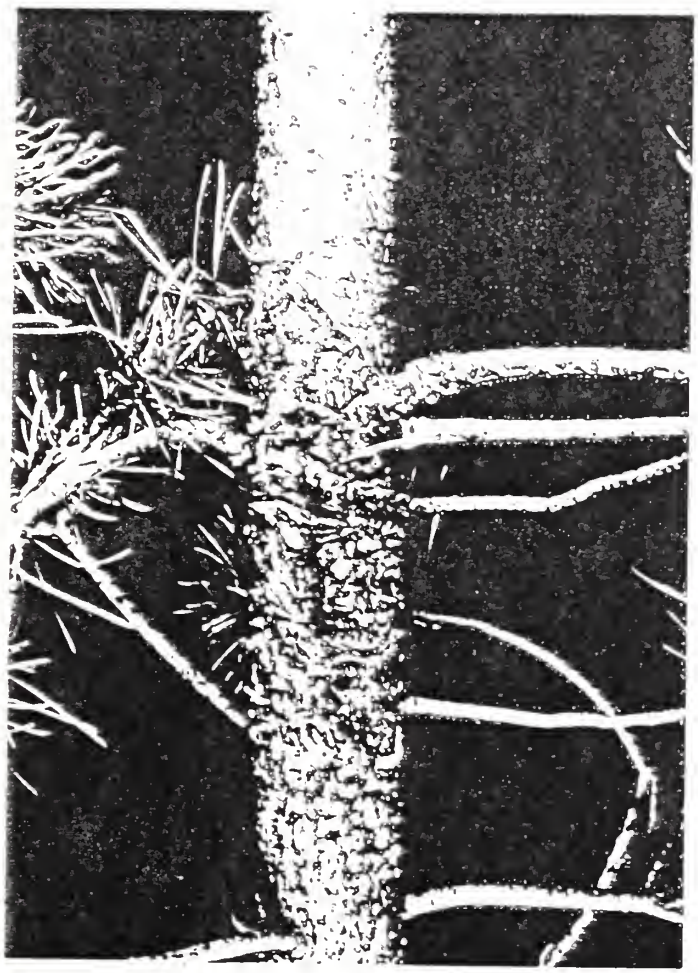


FIGURE 2

Young comandra rust canker showing bark cracks and fissures resulting from aecial spore production

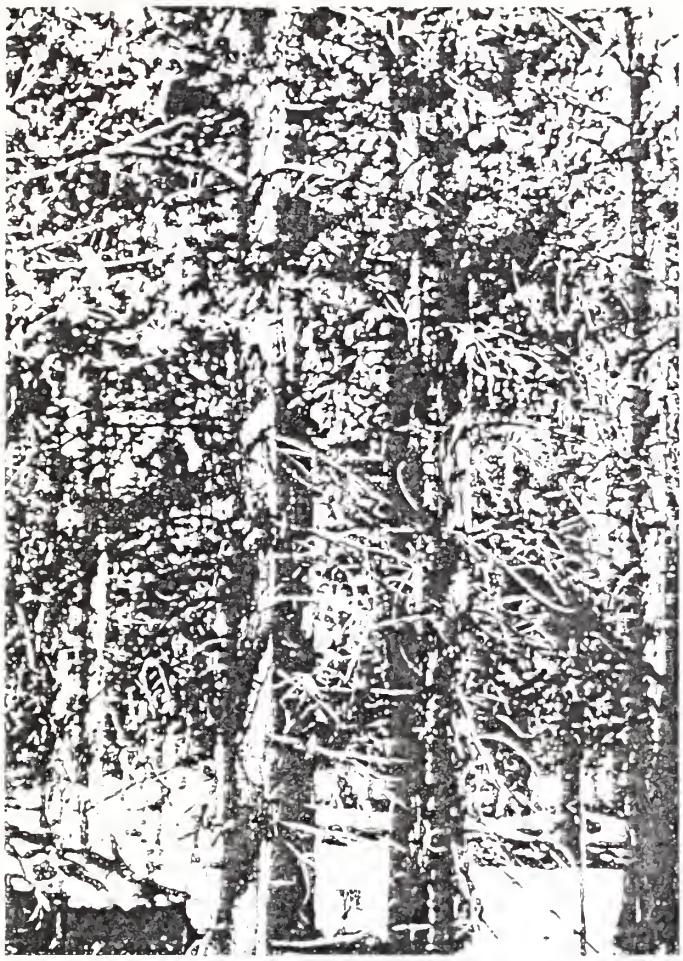


FIGURE 3

Two girdling and rodent chewed comandra rust cankers on lodgepole pine

FIGURE 4

Spike top condition caused by comandra rust on older lodgepole pine

FIGURE 5 Typical comandra plant habitat

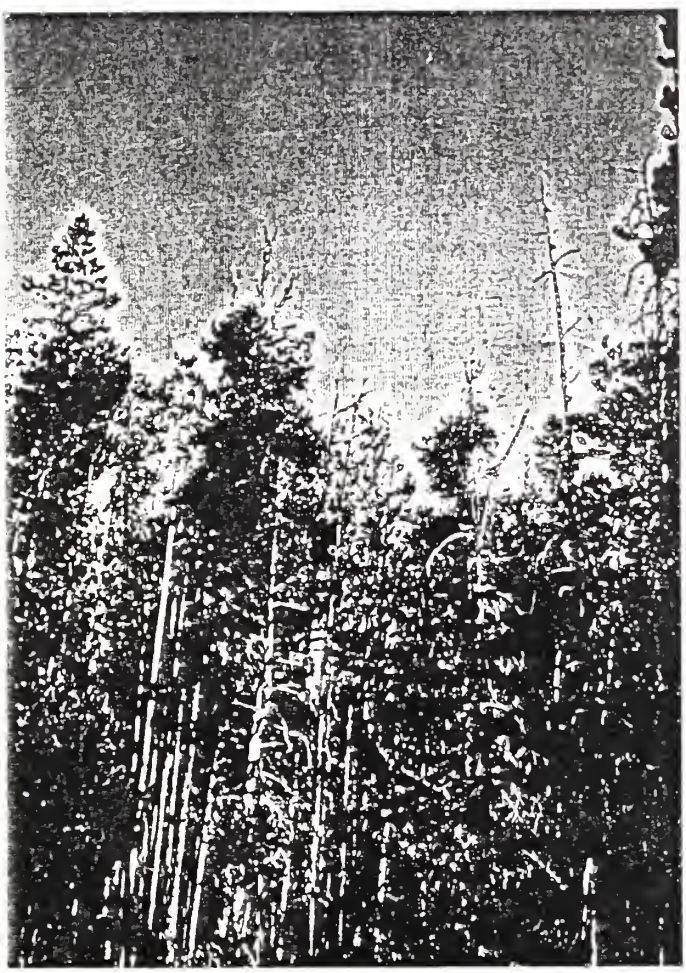


FIGURE 6

Lodgepole pine dwarf mistletoe infection center

found within lodgepole pine stands except in the most open or understocked stands (11). Comandra plants occur as aggregated populations among sagebrush especially where there is only light competition from grasses and herbaceous plants (Figure 5).

Current control recommendations for the rust are intended to reduce the incidence of the disease rather than preventing infections. One option is to salvage or cut the most heavily infected stands while the trees are still useable (13). Pruning infected branches may be useful to prolong the life of high value trees. However, there are no operationally successful methods to remove or prevent infections on the pine host.

Lodgepole pine dwarf mistletoe, *Arceuthobium americanum* Nutt. ex Engelm. causes growth loss, deformity and mortality of lodgepole pine throughout the natural range of the tree (5). The disease is spread by seed directly from pine to pine and generally is aggregated in its distribution over a stand. This results in concentrated centers of infection and damage (Figure 6). The disease attacks trees of all ages and size classes. Heavy damage generally occurs in stands with a history of partial cutting particularly when measures were not taken to intentionally reduce the incidence of dwarf mistletoe (Figure 7).

Clearcutting is the most effective method to control dwarf mistletoe. However, more recently the use of this silvicultural method has been restricted. Partial cutting is coming into more widespread use. Partial cutting can be a useful control measure if infected stands are properly managed (1). Proper timing and correct action are essential in reducing the incidence of dwarf mistletoe. Both comandra rust and dwarf mistletoe can occur within the same stand producing an even greater impact on tree growth and mortality.

FIGURE 7

Partial cut stand of lodgepole pine with heavy amounts of dwarf mistletoe

FIGURE 8

Pole size stand in Long Creek, Wind River District, damaged by rust

SCOPE OF THE PROBLEM IN REGION 2

Disease Incidence and Loss

Comandra blister rust has been observed throughout much of the lodgepole pine type in Colorado and Wyoming especially in stands over 80 years old. The exact distribution of the disease is not known. Based on data from sample plots established by Peterson (1962) and Krebill (1965) the average incidence of rust in the Bighorn and Shoshone National Forests would be approximately 25 percent.

Current disease impact consists primarily of spike tops, growth loss and mortality in pole- to sawtimber-size trees (Figure 8). Impact or loss data for the lodgepole pine resource affected by the rust are not available. Data from 49 temporary study plots, established in the Bighorn, Medicine Bow and Shoshone National Forests in 1975 and 1976, show a considerable range of rust incidence (Table 1). These plots are samples from rust infected stands only, representing a range of stand conditions. They do not represent the average condition of lodgepole pine stands in these Forests. All but two of the plots for the Shoshone National Forest were from the Wind River Ranger District. The highest concentration of rust incidence and damage on lodgepole pine in the Rocky Mountain Region has been observed along the northside of the upper Wind River drainage in the Shoshone National Forest in western Wyoming. In 11 study plots, representing seedling-sapling size stands (0.1 - 4.9" average d.b.h.) in the Shoshone National Forest, rust incidence ranged from 4.0 to 31.3 percent while rust caused mortality ranged from 1.2 to 24.3 percent. However, only two plots had rust caused mortality of over 10 percent. For the 22 plots in the Shoshone National Forest in pole- to sawtimber-size stands (5.0" or more average d.b.h.) rust incidence ranged from 15.7 to 73.9 percent, tree mortality from 1.0 to 29.4 percent and spike top condition from 15.7 to 69.3 percent. Rust incidence generally appeared to increase with decreasing stand density and with increasing average d.b.h. The data from these plots are being used to modify the simulation yield programs as explained later in this report. In none of the plots were there any large openings as a result of rust-caused mortality.

TABLE 1 SUMMARY OF 49 COMANDRA RUST STUDY PLOTS ESTABLISHED IN WYOMING IN 1975 and 1976.

AVERAGE D.B.H.	TREES PER ACRE	PERCENT COMANDRA RUST	PERCENT SPIKE TOPS	COMANDRA RUST RATING (CRR) [1/]	DWARF MISTLETOE RATING (DMR) [2/]	AVERAGE AGE	NATIONAL FOREST
1.4	7,692	5.0	-	0.4	1.5	33	Shoshone
1.5	7,615	11.1	-	0.8	-	28	"
1.7	4,304	7.1	-	0.4	-	15	"
1.8	5,210	4.0	-	0.3	0.3	23	"
1.9	6,250	8.0	-	0.4	-	20	"
2.1	2,083	15.0	-	0.7	-	24	"
2.3	1,695	8.0	-	0.4	-	18	"
3.6	1,381	7.9	7.9	0.6	-	58	"
3.6	1,203	31.3	27.7	1.4	-	102	"
4.0	1,194	15.1	13.9	1.0	4.9	58	"
4.9	1,081	25.0	20.0	1.2	-	59	"
5.0	781	29.3	21.3	1.9	0.1	53	"
5.9	840	47.6	44.0	1.5	3.8	89	"
7.4	415	73.9	69.3	2.5	3.6	107	"
7.4	657	54.7	50.0	1.8	2.4	184	"
7.6	622	15.7	15.7	0.6	5.3	115	"
7.7	423	27.1	21.2	1.1	-	103	"
7.7	647	27.8	20.0	1.5	-	80	"
7.9	460	67.8	55.2	2.1	4.3	169	"
7.9	339	65.9	61.1	3.1	2.4	124	"
8.2	391	73.4	58.2	2.3	-	104	"
8.6	477	50.8	31.7	2.4	-	86	"
8.7	321	36.8	34.5	1.6	-	126	"
9.1	294	61.3	58.1	2.3	2.9	139	"
9.3	281	62.4	60.2	2.1	-	133	"
9.5	279	44.4	36.7	1.2	2.8	190	"
10.3	196	53.3	50.0	2.1	3.5	113	"
10.3	214	47.9	44.8	1.5	2.3	198	"
10.3	259	26.7	26.7	0.6	3.7	196	"
11.5	373	60.6	57.4	1.7	-	210	"
12.2	171	28.1	21.1	0.8	4.4	202	"
13.1	237	19.3	17.1	0.5	3.4	250	"
3.5	3,478	5.0	3.6	0.2	-	80	Medicine Bow
5.9	900	6.7	1.1	0.3	-	80	"
6.1	1,203	4.5	2.2	0.1	-	86	"
7.0	445	24.5	12.2	1.2	-	80	"
7.3	474	9.1	4.0	0.4	-	86	"
8.0	257	17.9	8.4	0.9	-	80	"
8.9	285	8.4	4.2	0.4	-	86	"
9.2	198	8.1	6.1	0.4	-	86	"
7.6	851	13.4	12.4	0.7	-	161	Bighorn
8.7	479	18.5	15.2	0.9	-	164	"
9.3	444	19.6	17.4	0.9	1.1	169	"
9.8	250	30.1	28.0	1.3	-	162	"
10.2	264	10.9	9.8	0.4	1.1	190	"
10.8	293	17.0	16.0	0.6	2.0	170	"
11.2	190	12.1	12.1	0.5	2.7	171	"
11.3	151	24.8	24.8	1.2	-	168	"
12.5	187	24.0	20.9	1.3	-	157	"

1/ See Figure 10

2/ See Figure 11

Rust incidence and damage in pole- and sawtimber-size stands in the Bighorn and Medicine Bow National Forests appears to be considerably less than for the Shoshone National Forest. One possible reason is the greater interspersion of comandra habitat with lodgepole pine in the Shoshone National Forest. Infected trees were quite evenly scattered in many stands of the Bighorn and Medicine Bow National Forests. Stands with 10 percent or more of the trees infected with rust were difficult to find. The infected trees, many of which are now dead or dying, became infected when the stands were much younger. Many of the trees have spike tops and are in the intermediate and suppressed crown classes. The death of these trees will not significantly affect tree stocking or volume production and may result in a light thinning.

Lodgepole pine dwarf mistletoe, the most widely distributed dwarf mistletoe in North America, has infested an estimated 50 percent of all the commercial lodgepole pine forests in Region 2 (7). The disease affects all age classes but is particularly damaging in partial cut stands where dwarf mistletoe control was not considered. Studies show that stands heavily infested with the disease have about half the volume and twice the mortality rate of non-infested stands on comparable sites (7). A comparison of estimated acreages infested by size classes for the Bighorn, Shoshone and Medicine Bow National Forests is shown in Table 2. The major impacts of the disease are growth loss and mortality. Spike tops, caused by this disease, occur mainly in heavily infected pole and sawtimber stands. Since comandra rust also causes spike top trees it is necessary to distinguish between the effects of the two diseases. Rust cankers after killing the top continue to spread down the stem lengthening the dead top as whorls of branches are pro--gressively killed. Recent rodent chewing and pitch flow are usually prominent features around rust cankers (Figure 3). In contrast, spike tops caused by dwarf mistletoe, show little or no rodent chewing or pitch flow, usually have dead brooms or swellings on dead branches, have mistletoe shoots on live branches and brooms and frequently have upturned laterals (Figure 9). In some cases trees may be infected with both diseases and display mixed symptoms.

Table 2 - 1974 estimates of commercial acreages of lodgepole pine infested with dwarf mistletoe for three size classes in the Bighorn, Shoshone and Medicine Bow National Forests.

NATIONAL FOREST	SIZE CLASS	COMMERCIAL FOREST ACREAGE [1] TOTAL ACRES	INFESTED WITH [2] DWARF MISTLETOE ACRES	PERCENT
Bighorn	sawtimber	135,794	54,318	40
	pole	112,720	18,035	16
	seedling - sapling	50,575	5,058	10
Shoshone	sawtimber	73,602	42,689	58
	pole	83,619	20,068	24
	seedling - sapling	- [3]	-	--
Medicine Bow	sawtimber	208,800	125,280	60
	pole	94,655	25,557	27
	seedling - sapling	64,072	12,814	20

[1] Data taken from Timber Management Plans, Region 2.

[2] Percentage of dwarf mistletoe adapted from Hawksworth, 1958.

[3] Figures not available

FIGURE 9 Spike top on lodgepole pine caused by lodgepole pine dwarf mistletoe showing upturned lateral (compare with Figure 4).

MANAGEMENT IMPLICATIONS AND OPPORTUNITIES

The dilemma now facing the land manager particularly for the Wind River Ranger District of the Shoshone National Forest is what to do with rust infested stands. Even though practical methods of control for comandra rust are not available, damage can be reduced. Low incidence of the rust, particularly in dense stands, usually results in a light thinning. Timber cutting should be conducted first in the more heavily infected stands where in some cases stand removal and replacement may be the only option. The inventory of heavily damaged stands should be converted as rapidly as possible to productive stands. More management opportunities are available for light to moderately infected stands. In the case of intermediate cuts or thinnings remove as many trees with stem cankers and spike tops as possible without removing more than the recommended basal area; leaving a few infected trees is less of a risk than opening up the stand too much (1). In any case the most heavily infected or seriously damaged trees should be removed first.

Dwarf mistletoe, in contrast to the current rust problem, continues to intensify in infected stands and therefore must be handled differently. Much has been written and put into practice, for the control of dwarf mistletoe in lodgepole pine. Recently published silvicultural guidelines (3) offer the land manager the following range of control alternatives:

No control -- Conduct normal management activities; any reduction in the incidence of dwarf mistletoe is incidental and not a planned action. This is a viable alternative where:

1. Less than 10 percent of the stand is infected. Normal thinning activities will keep infection levels low enough to ensure good growth.

2. Removal of all DMR Class 3 and higher trees would result in an understocked stand.

3. Management activity is not feasible until a commercial entry can be made and the unmerchantable portion of the stand destroyed after product removal.

4. The lodgepole pine currently on the area is the last generation. The stand is converting to climax.

Complete control -- Completely destroy heavily infested young stands or remove all trees over 1 foot in height from clearcut stands or burned-over areas. This is a viable alternative where:

1. A young stand is so heavily infested that a commercial harvest cannot be realized within one normal rotation (90 to 120 years).

2. The stand has recently been clearcut, but some unmerchantable infected whips are still present.

3. The stand has been burned within the past 10 years but not all infected trees were killed by the fire or removed in salvage operations.

Partial control -- Reduce infection to levels that do not seriously affect timber production by removing all overstory trees and all DMR Class 3 and higher trees in the understory during combined thinning/sanitation. This is a viable alternative where:

1. The stand is less than 40 percent infected and an infested overstory was or is present.

2. The stand has been regenerated by a shelterwood or seed tree cut and the infected seed trees have not been removed.

3. The stand was burned-over more than 10 years ago, regeneration has occurred, and an infested overstory is present.

The basic principle of control is the removal of infected trees which are the source of dwarf mistletoe seeds that spread the disease from tree to tree. This reduces the proportion of infected trees within the stand and thereby slows the progress and impact of the disease. The removal of infected overstory trees in cutover stands, preferably within 10 years, of successful regeneration, is important to prevent the regeneration from becoming infected. Thinning should not be attempted in stands with more than 40 percent of the trees infected. Detailed studies have shown that after careful removal of all visibly infected trees that half again as

many trees were found infected within 5 years (8). Periodic stand entries are desirable to remove infected trees and further reduce the incidence of the disease.

The land manager has a tool available in the recently developed simulation yield programs to aid him in making management decisions for stands under consideration. These programs produce a printout of a management scheme including intermediate cuts and final harvest showing yield projections, based on current stand conditions. The projections can be varied by altering the input data to achieve different management objectives. The land manager then selects the scheme that best fits the management goal and restraints for that particular stand. The newest program, RMYLD, is a composite of what were separate programs for ponderosa pine, lodgepole pine, and Engelmann spruce - subalpine fir (4). The lodgepole pine subroutine of RMYLD has been modified to include the effects of dwarf mistletoe and will be modified for the effects of comandra rust on lodgepole pine yield. The user of RMYLD must indicate, in the required data inputs, the tree species and for lodgepole pine the presence or absence of dwarf mistletoe and comandra rust. The disease input values are average estimates of the incidence and intensity of each disease for the stand under consideration. These estimates are obtained from individual tree ratings using a similar numerical rating system for each disease. These systems, called comandra rust rating (CRR) and dwarf mistletoe rating (DMR) are explained in Figures 10 and 11 respectively. The two rating systems are intended for pole size or larger trees. Both rating systems should be used in Stage 1 and Stage 2 inventories. Trees can be rated and the values recorded during stand examinations or surveys. A survey procedure to collect the required inputs for RMYLD, can be conducted with minimum cost when such information is not otherwise available (2). Yield projections for infected stands are then used by the land manager to evaluate treatment feasibility and priorities.

One important difference between dwarf mistletoe and comandra rust in these stands at the present time is that the former continues to intensify over time through new infections while the latter does not. One feature then not automatically included in the projection of yield for rust infected stands is the prediction and projected effect of new infections. The user of the modified RMYLD then must indicate the occurrence of new infections if and when they occur in order to determine their effect on yield. The yield projections, in each case show how management practices can minimize impact by slowing disease intensification in the case of dwarf mistletoe and slowing stand deterioration in the case of comandra rust.

FIGURE 10 Comandra Rust Rating (CRR) System

INSTRUCTIONS

STEP 1. Divide crown (live & dead portions) into thirds

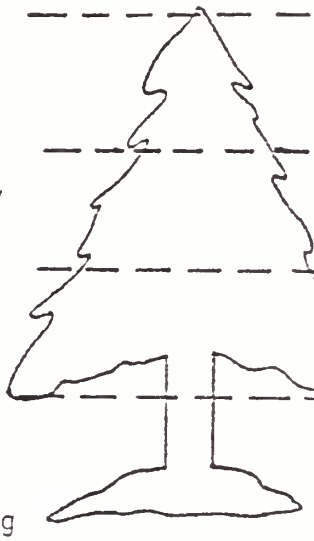
STEP 2. Rate each third separately using only the most serious canker in any third according to the following values:

crown third	non-girdling stem canker	girdling stem canker
upper	1	2
middle	2	4
lower	4	8

When more than one girdling canker occurs on a tree, rate only the lowest one. Cankers located below the live crown are rated the same as the lower third.

STEP 3. Total the ratings for the entire tree.

EXAMPLE



If this third has no visible infection; its' rating is 0

If this third has a girdling stem canker its' rating is 4

If this third has a non-girdling stem canker, its' rating is 4

The tree in this example will receive a total rating of 8

RATING SCALE: 0 - 8

FIGURE 11 Dwarf Mistletoe Rating (DMR) System

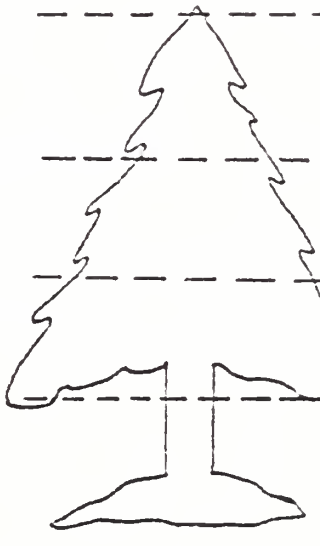
INSTRUCTIONS

STEP 1. Divide live crown into thirds.

STEP 2. Rate each third separately. Each third should be given a rating of 0, 1 or 2 as described below:
0 No visible infections
1 Light infection (½ or less of total number of branches in the third infected.)
2 Heavy infection (more than ½ of total number of branches in the third infected).

STEP 3. Finally, add ratings of thirds to obtain rating for total tree.

EXAMPLE



If this third has no visible infections, its' rating is 0

If this third is lightly infected, its' rating is 1

If this third is heavily infected, its' rating is 2

The tree in this example will receive a total rating of 3

RATING SCALE: 0 - 6

FIGURE 12 SUGGESTED CRITERIA FOR LEAVE TREE SELECTION IN COMANDRA RUST AND DWARF MISTLETOE INFESTED LODGEPOLE PINE STANDS

TREE CONDITION	LEAVE TREE PREFERENCE
1. Apparently disease free	Most desirable
2. DMR of 2 or less (no rust)	
3. Non-girdling rust canker - CRR of 2 or less (no mistletoe)	
a. $\leq$ ½ around circumference	
b. $>$ ½ around circumference	
4. Girdling stem canker - CRR of 4 or less (no mistletoe)	
a. upper 3rd	
b. middle 3rd	
5. Spike top - CRR of 4 or less (no mistletoe)	
a. $\geq$ ½ live crown	
b. $<$ ½ live crown	
6. Cankers in lower 3rd or less than 10' of live crown remaining	
7. Multiple stem cankers	
8. Any rust and DM combination	Least desirable

When applying a management option from RMYLD to an actual stand where tree cutting is anticipated, the leave trees should be carefully selected. A list of criteria for leave tree selection, in decreasing order of desirability, is shown in Figure 12. Obviously the most desirable leave trees are those that are disease free or only lightly infected. This is particularly true when selecting seed trees. If it is necessary to leave infected trees to maintain adequate stocking select those less seriously damaged from rust, instead of dwarf mistletoe infected trees.

RECOMMENDATIONS FOR ADDITIONAL STUDY

A separate study will be needed to verify the yield projections from RMYLD for rust infected stands. This could be done by using a proposed thinning project in an infected stand to obtain measurements before and after treatment. The criteria for leave tree selection can also be verified and modified as necessary during the study.

A general incidence survey is needed to determine the distribution of comandra rust throughout the commercial lodgepole pine type in Region 2. A special survey should be conducted in stands under 50 years of age in the Wind River Ranger District, where rust damage in general has been the heaviest, to determine the incidence of newer infections. A study of the fate of rust cankers on trees less than 30 years of age, begun in 1973, in the Wind River Ranger District, should be continued. Further study is needed to determine the probabilities of successful invasion of the stem by branch cankers originating at various distances from the stem.

Several areas of potential study where information is needed is the spatial relationship, direction and distance, between lodgepole pine and other plant communities where comandra plants are present; the phenomenon of wave years on infection cycles of the rust; and the impact and implications of stands infected with both comandra rust and dwarf mistletoe.

REFERENCES

1. ALEXANDER, R. R. 1975. Partial cutting in old-growth lodgepole pine. USDA, For. Serv. Res. Paper RM-136. Rocky Mtn. For. and Range Exp. Sta. Fort Collins, Colorado. 17 pp.

2. BROWN, D. H. 1977. An evaluation survey procedure for dwarf mistletoe and comandra blister rust in proposed thinning projects. USDA, Forest Service, Forest Insect and Disease Mimeograph report, Rocky Mountain Region, Denver Colorado.

3. DOOLING, O. J. and D. H. BROWN. 1976. Guidelines for dwarf mistletoe control in lodgepole pine in the northern and central Rocky Mountains. For. Evir. Protection Report 76-14. 10 pp.

4. EDMINSTER, C. B. 1977. RMYLD: Computation of yield tables for even-aged and two-storied stands. USDA, For. Serv. Res. Pap. Rocky Mtn. For. and Range Exp. Sta. Fort Collins, Colorado. (In Press)

5. GILL, L. S. and F. G. HAWKSWORTH. 1964. Dwarfmistletoe of lodgepole pine. USDA Forest Pest Leaflet 18. 7 pp.

6. HAWKSWORTH, F. G. 1958. Survey of lodgepole pine dwarf-mistletoe on the Roosevelt, Medicine Bow and Bighorn National Forests. USDA, For. Serv. Sta. Pap. 35. Rocky Mtn. For. and Range Exp. Stn. Fort Collins, Colorado. 13 pp.

7. HAWKSWORTH, F. G. 1975. Dwarf mistletoe and its role in lodgepole pine ecosystems. IN Management of lodgepole pine ecosystems, Symposium Proc. Vol. 1:342-358. Wash. State Univ. Pullman, Washington.

8. HAWKSWORTH, F. G., T. HINDS, D. W. JOHNSON and T. D. LANDIS. 1977. Silvicultural control of dwarf mistletoe in young lodgepole pine stands. Tech. Rep. R2-10. Rocky Mountain Region, Denver, Colorado.

9. KREBILL, R. G. 1965. Comandra rust outbreaks in lodgepole pine. J. For. 63:519-522.

10. KREBILL, R. G. 1968. *Cronartium comandrae* in the Rocky Mountain states. Research Paper, INT-50, Intermountain For. and Range Exp. Sta. Ogden, Utah. 28 pp.

11. KREBILL, R. G. 1975. Lodgepole pine's fungus-caused diseases and decays. IN Management of lodgepole pine ecosystems, Symposium Proc. Vol. 1:377-405. Wash. State Univ. Pullman, Washington.

12. MIELKE, J. L. 1957. The comandra blister rust in lodgepole pine. Res. Note. 46. Intermountain For. and Range. Exp. Sta. Ogden, Utah. 8 pp.

13. MIELKE, J. L., R. G. KREBILL and H. R. POWERS, Jr. 1968. Comandra blister rust of hard pines. USDA, Forest Pest Leaflet 62. 8 pp.

14. PETERSON, R. S. 1962. Comandra blister rust in the central Rocky Mountains. Res. Note 79. Rocky Mountain For. and Range Exp. Sta. Fort Collins, Colorado. 6 pp.

15. PETERSON, R. S. and F. F. JEWELL. 1968. Status of American stem rusts of pine. Ann. Rev. of Phytopath. 6:23-40.